METAL INJECTION MOLDING FURNACE HEATING ELEMENT ADJUSTMENT APPARATUS

BACKGROUND OF THE INVENTION

Technical Field

The present invention relates generally to metallurgical furnaces, and more particularly to an adjustment mechanism for selectively positioning resistance heating elements in an electric metal injection-molding holding furnace which uses electrical resistance elements to radiate thermal energy to aluminum in a heating chamber.

Background Art

For several decades it has been known to employ electrically energized resistance elements in metallurgical furnaces to melt various metals and alloys, particularly nonferrous metals such as aluminum and zinc. Silicon carbide heating elements (glow bars) have been found to be especially well suited to melting aluminum, both indirectly through the heating of the furnace atmosphere and directly by contact with the elements. Silicon carbide glow bars are the preferred instrument for providing heat to the molten metal reservoir of a pressurized injection molding holding furnace.

However, glow bars, which are cylindrical to maximize surface area for transferring heat to the gaseous or metallic medium, are generally stationary because they are cradled in a fixed rack within the furnace. While this provides a measure of stability it also necessitates that the heating elements be cooled, removed, and repositioned for any changeovers to a new mold or when feed tubes (riser tubes) for injecting molds must be repositioned.

Accordingly, there exists a need for a method and apparatus adapted for quick and easy repositioning of furnace glow bars.

Disclosure of Invention

The heating element adjustment device of the present invention provides an adjustment mechanism for rapid selective positioning of electrical resistance heating elements in electric pressurized metal injection molding furnaces, such as are employed in metal injection mold casting processes involving upward filling. A suitable furnace for employing the present invention is preferably cuboid and includes a steel case and a lined reservoir for molten metal. Molten metal, which is typically of a non-ferrous nature, is pumped upwardly through feed tubes under gas pressure. When operating, the furnace is hermetically sealed, the seal being maintained in part by a top-side pressure tight lid. A sealed panel integral with the lid includes one or more apertures through which feed tubes pass into the furnace reservoir.

Resistance heating elements are inserted through a side heating element door or doors and are disposed horizontally in either a heating element box or a set of paired boxes positioned on opposite sides of the furnace. A portion of each element is left uninsulated or unshielded so that heat can be radiated into the reservoir. The number of heating elements is a function of both the power supply system and the demands of the molds employed in the casting process.

The express purpose of the present invention is to facilitate the rapid, safe, and easy repositioning of silicon carbide (or other) resistance heating elements so that production is not slowed or impeded during mold changeovers and feed tube position changes when dies are changed or when shifting to a succeeding stage in the molding process. Further, the heating element adjustment device of the present invention enables operators to carefully control the flow and solidification of molten metal as it is delivered via feed tubes to an injection die by precisely positioning the heating elements in optimal locations relative to the feed tubes and to one another. Accordingly, the resistance heating element adjustment device of the present invention comprises means for selectively and independently positioning each one of a plurality of heating elements relative to one another and to the feed tubes employed in a casting process in any of an almost unlimited number of configurations.

Three preferred means of accomplishing such positioning are contemplated, though several others are possible. In a first preferred embodiment, the heating elements are moved and positioned in a rack and pinion system, each element having a dedicated rack and pinion gear assembly. In a second preferred embodiment, the heating elements are moved and

positioned by a timing chain drive assembly which includes one timing chain or a parallel set of timing chains for each heating element, each chain in mesh communication with a pinion gear. In a third preferred embodiment, a screw drive assembly is employed to move and position the heating elements.

Brief Description of the Drawings

The present invention is further described in detail in reference to the accompanying drawings, in which:

FIG. 1 is a schematic top view of a pressurized metal injection molding holding furnace showing a first preferred embodiment of the electrical resistance heating element adjustment device of the present invention;

FIG. 2 is a schematic side view in elevation of the heating element adjustment device of FIG. 1;

FIG. 3 is a schematic end view in elevation of the device of FIGS. 1 and 2;

FIG. 4 is a schematic top view of a holding furnace showing a second preferred embodiment of the heating element adjustment device of the present invention;

FIG. 5 is a schematic side view in elevation of the heating element adjustment device of FIG. 4;

FIG. 6 is a schematic end view in elevation of the device of FIGS. 4 and 5; and

FIG. 7 is a schematic side view in elevation of a third preferred embodiment of the heating element adjustment device of the present invention.

Best Mode for Carrying Out the Invention

Referring to FIGS. 1 through 7, wherein like reference numerals refer to like components in the various views, FIG. 1 is a schematic top view of a first preferred embodiment of the metal injection molding holding furnace heating element adjustment device of the present invention. FIG. 2 is a schematic side view in elevation of the heating element adjustment device of FIG. 1, and FIG. 3 is a schematic end view in elevation of the device of FIGS. 1 and 2. These views shown that the heating element adjustment device of the present invention is adapted for use in a pressurized metal injection molding furnace 10, such as is employed in a metal injection mold casting process involving upward filling. The furnace may take any of a number of suitable shapes, though a cube-like configuration is

most common. The furnace includes steel case 12 having a liner 14 encasing a reservoir 16 for holding molten metal 18. In operation the molten metal is pumped upwardly through feed tubes 20 under the pressure of an inert gas (pressure system not depicted), as is well known in the art. In operation, the entire furnace is hermetically sealed and includes a pressure tight lid 22 at its top. A sealed panel 24 is affixed to or integral with the lid. The panel 24 has one or more apertures 26 for the insertion of feed tubes through the lid and into the furnace reservoir 16. The positioning of the feed tubes in the panel is specific to the mold employed in the molding process. While the figures of the present application depict four feed tubes, as this number is somewhat typical and thus useful for illustrative purposes; however, it is also somewhat arbitrary and does not in any way restrict the scope of use of the adjustment device of the present invention: Any of a number of feed tubes may be deployed around and through the sealed panel as appropriate to the needs of the injection-molding process.

Resistance heating elements 28a, 28b, and 28c, preferably fabricated of silicon carbide (and commonly referred to as glow bars), are generally installed through one or more side heating element doors 30a, 30b, of the furnace. All of the heating elements are generally elongate and are disposed horizontally in a heating element box, 32a, 32b, 32c, leaving a portion 34 of the respective heating elements unshielded for the introduction of heat into the reservoir. As a general rule, the number of heating elements corresponds to the power supply system connected to the elements, thus multiples of three are most common for use with three-phase electric supply systems (not shown). The heating element door 30 includes a gasket 36 as part of the hermetically sealed, pressurized system.

In a first preferred embodiment, illustrated in FIGS. 1-3, the inventive system comprises a rack and pinion assembly, one set of rack and pinion gear assemblies for each heating element. In FIGS. 1-2, for instance, each one of the electrical resistance heating elements, each heating element cradled in a heating element box at each of its ends, are operatively connected to one rack and pinion assembly. Thus, each end of a heating element is operatively connected to a gear assembly. FIG. 2 shows that the entire rack and pinion assembly comprises an assembly housing 40 enclosing a plurality of vertically stacked pinions gear sets 42a, 42b, and 42c, in mesh and with corresponding rack sets 44a (FIG. 2 only), 44b, to produce reciprocating motion of the racks and thus of the respective attached heating element boxes, 32a, 32b, or 32c. FIG. 1 shows that the vertically stacked parallel sets of rack and pinion gears, collectively denominated 45a-b, are positioned on opposite sides of

the furnace, and each rack and pinion set (or combination) is coupled to one end of a heating element via a heating element box, such that each member of a rack and pinion gear set is operatively coupled to an end of a heating element. When three heating elements are employed, the heating element boxes 32a most proximate the assembly housing are connected to the middle rack set 44a, and the two more distal heating element boxes, 32b and 32c, are coupled to upper and lower rack sets, 44b and 44c, respectively. Thus, the racks and the heating element boxes may be moved independently of one another. Timing shafts 46 enclosed in elongate housing 48 and spanning to connect the individual members of each pinion gear set of the parallel rack and pinion assemblies 45a-b ensure synchronous movement of rack and pinion set (or combination) and thus of each heating element end. The assembly may be tuned and adjusted via adjustment shaft 50, which permits fine tuning and positioning of the heating elements relative to one another. As will be readily appreciated by those with skill in the art, movement of the assembly may be actuated manually or with any of a number of suitable motor drives for selectively moving any one or a combination of the rack and pinions.

FIG. 4 is a schematic top view of a holding furnace showing a second preferred embodiment of the heating element adjustment device of the present invention. FIG. 5 is a schematic side view in elevation of the heating element adjustment device of FIG. 4, and FIG. 6 is a schematic end view in elevation of the device of F IGS. 4 and 5. As shown in FIGS. 4-6, the second preferred embodiment of the heating element adjustment device of the present invention comprises a timing chain drive assembly which includes parallel timing chains 60, 62, and 64, each connected to a heating element box one each dedicated to actuating the movement of a respective heating element 28a, 28b, 28c, each chain in mesh communication with a corresponding pinion gear, 68, 70, 66, respectively. FIGS. 4 and 5 show that timing chains 60, 62, and 64 and pinion gears, 66, 68, and 70, function similarly to the rack and pinion assembly of the first preferred embodiment, described above. Pinions 66, 68, and 70, are connected to pinions 72, 74, and 76 via drive chain timing shafts 78a, 78b, and 78c. As with the rack and pinion embodiment, the timing chain system is enclosed in a protective housing 80, and, again, the assembly may be adjusted via a chain drive adjustment shaft 82 (FIG. 6). As will be readily appreciated, independent and discrete movement of each of the heating elements can be effected through the separated timing chains and pinion gears.

In a third preferred embodiment, illustrated in FIG. 7, a screw drive assembly 90 is

employed as the actuating means. In this embodiment the fundamental principle of selective and independent movement of the heating elements is preserved and elements substantially identical to those of the first and second preferred embodiments are employed. However, rather than a rack and pinion gear assembly or a timed chain drive assembly, the means of moving each heating element comprises a dedicated screw drive, enclosed by an airtight housing 92, each screw drive comprising an acme screw 94a, 94b, and 94c, and a corresponding worm gear 96a, 96b and 96c, such devices being well known in the art. This view also shows exhaust ports 98 through which pressurized gas is released before doors are open or feed tubes removed.

In another aspect, the present invention may be characterized as an improved metal injection-molding holding furnace, wherein the improvement comprises the inclusion of the above-described adjustment mechanism for selectively positioning resistance heating elements that radiate thermal energy to aluminum in the furnace heating chamber.

In yet another aspect, the present invention may be characterized as a method of independently and selectively moving and positioning a plurality of electric furnace resistance heating elements by providing and employing the above-described adjustment mechanism

While this invention has been described in connection with preferred embodiments thereof, it is obvious that modifications and changes therein may be made by those skilled in the art to which it pertains without departing from the spirit and scope of the invention. Accordingly, the scope of this invention is to be limited only by the appended claims.